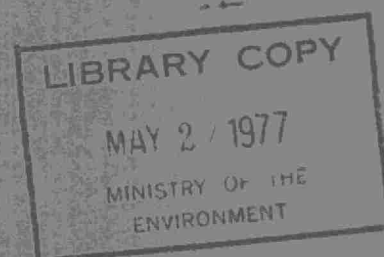


WATER QUALITY OF THE EASTERN PORTION OF LAC DES MILLE LACS DISTRICT OF THUNDER BAY

1977



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Ministry
of the
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L. F. Pitura
Director
Northwestern Region

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REPORT OF WATER QUALITY
OF THE EASTERN PORTION OF LAC DES MILLE LACS
DISTRICT OF THUNDER BAY
1977

D. J. Hollinger and J. Vander Wal
Water Resources Assessment
Technical Support Section
Northwestern Region
Ontario Ministry of the Environment

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INTRODUCTION

During the spring and summer of 1976, Ministry of the Environment staff conducted a water quality investigation on the eastern portion of Lac des Mille Lacs which included an examination of chemical, bacteriological and biological parameters. The 1976 survey, which comprises the first part of a two year programme, was initiated since it was recognized that Lac des Mille Lacs has in recent years gained rapidly-increasing popularity as a recreational area to both local residents and tourists, and that a potential increase in cottage development might give rise to associated water quality deterioration.

The following report is of a preliminary nature and includes information which will aid in: (1) the documentation of trophic status, (2) assessing proposed cottage development on the basis of water quality criteria, and (3) delineating specific aspects which will be of interest in future studies. Additional conclusions regarding the water quality status of Lac des Mille Lacs will be made at such time that data collection for the whole lake system has been completed.

DESCRIPTION OF THE STUDY AREA

Lac des Mille Lacs, located in Northwestern Ontario, is approximately 100 kilometres northwest of the City of Thunder Bay at a latitude $48^{\circ} 50'N$ and longitude $90^{\circ} 30'W$. Morphometric characteristics include total surface area of 24,000 ha, a perimeter of 450 kilometres and mean and maximum depths of 6.8 m and 24.5 m respectively. Geological features include Precambrian bedrock with associated outcroppings overlain by sand, fine till and boulders. The area receives a mean annual rainfall of 68.6 cm and a mean annual snowfall of 203.2 cm. The mean July and January temperatures are $18^{\circ}C$ and $-16^{\circ}C$ respectively.

Mixed deciduous-coniferous stands predominate the area as is typical of the Great Lakes - St. Lawrence forest region. Dominant tree species include black spruce (Picea mariana), white spruce (Picea glauca), jackpine (Pinus banksiana), white pine (Pinus strobus), trembling aspen (Populus tremuloides), balsam poplar (Populus balsamifera) and white birch (Betula papyrifera).

The more important fish species inhabiting the lake are walleye (Stizostedion vitreum vitreum), pike (Esox lucius), yellow perch (Perca flavescens), lake whitefish (Coregonus clupeaformis), cisco (Coregonus artedii), burbot (Lota lota), white sucker (Catostomus commersoni), longnose sucker (Catostomus catastomus) and a number of forage fish species. Walleye and pike constitute the species which are of most importance to anglers. Although commercial fishing for walleye, pike and lake whitefish is still actively undertaken, the practice is being phased out in light of increasing significance of the sport fishing harvest (Elsey and Thomson, 1976).

Lac des Mille Lacs is also used for camping and tourist outfitting. At present, there are 12 tourist resorts and 78 private cottages in use. The major areas of development are Open Bay, Pine Point, Honkonen Narrows, and the Savanne and Seine Rivers. Water levels are controlled by an Ontario Hydro dam situated at the northwest end of the lake which results in a maximum annual fluctuation of 0.54 m (Elsey and Thomson, 1976).

FIELD AND LABORATORY METHODS

Five water quality stations were selected at sites of major cottage development (Figure 1). Samples for chemical analyses were collected from the epilimnion at 1.0 m below the surface and from the hypolimnion at 1.0 m above the bottom using a Van Dorn water sampler. Chemical and bacteriological determinations were conducted in accordance with "Standard Methods for the Examination of Waters and Waste Waters, 1975" as well as additional techniques being presently documented by the Ministry of the Environment. Determination of oxygen concentrations and temperatures were made using a Y.S.I. model 54 oxygen-temperature meter. Bacteriological samples were taken from the surface waters only.

Chlorophyll $\bar{a}$ samples were collected in 1-litre glass bottles as composite samples from the euphotic zone. The depth of the euphotic zone was theoretically determined as twice the Secchi disc depth to

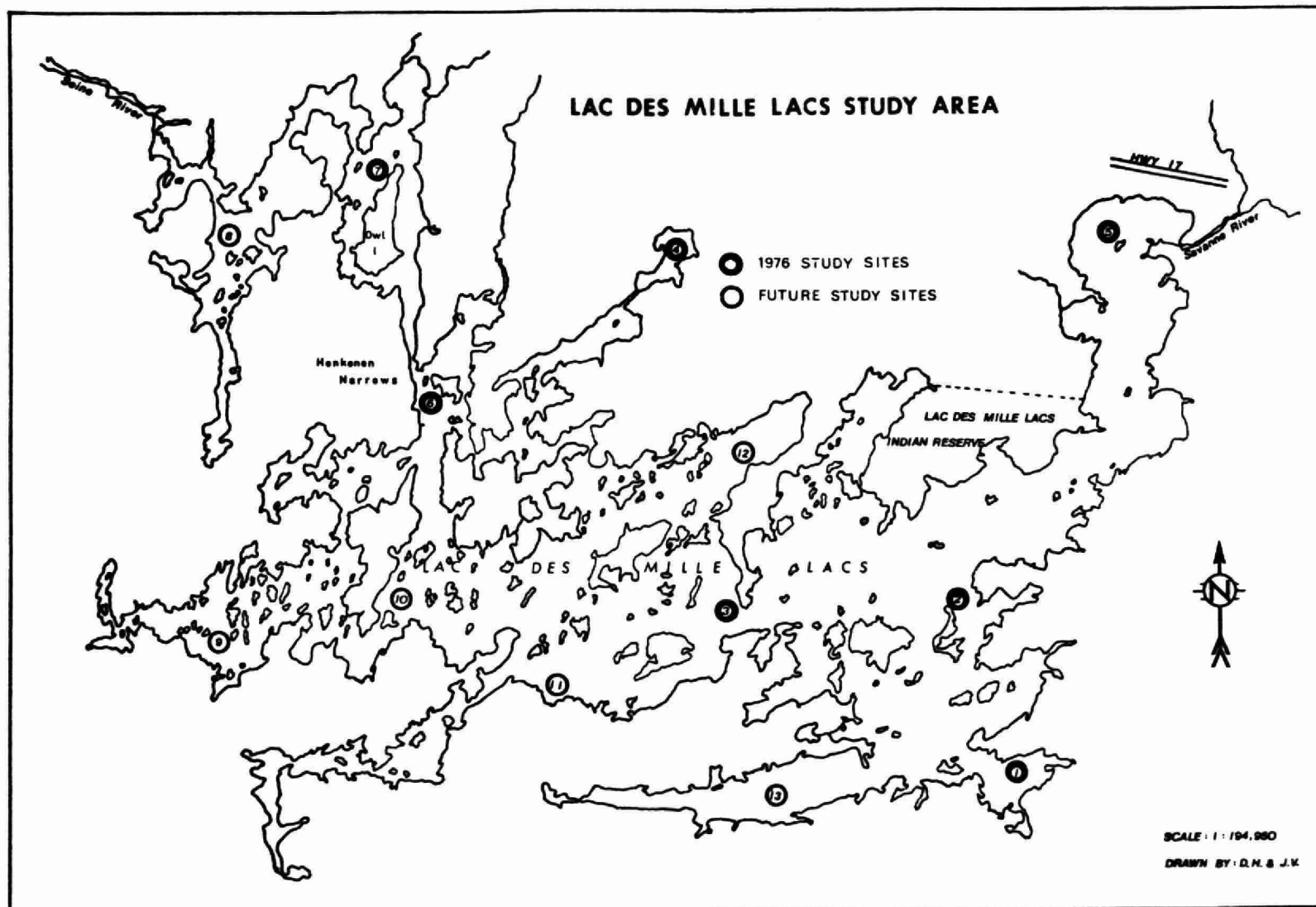


FIGURE 1 LAC DES MILLE LACS STUDY AREA

approximately yield the level of 1% incident light. Samples were preserved in the field with 3 ml of 2% magnesium carbonate, placed in a cooler and transported to the laboratory. At the laboratory, 300 - 1,000 ml of the sample were filtered through 1.2 μ "Millipore" filter paper with the use of a vacuum pump at approximately 1.0 kg cm⁻². The chlorophyll concentrations were determined by 90% acetone extraction followed by reading of per cent wavelengths using a Beckman spectrophotometer.

In addition to the 5 water quality stations 2 stations were sampled for Secchi disc depth and chlorophyll $\bar{a}$ under the Self-Help Programme. One such station at Honkonen Narrows and another located northwest of Owl Island (Figure 1) were sampled weekly from May to September.

RESULTS AND DISCUSSION

Bacteriological Results

Recreational waters can be considered impaired when coliform, fecal coliform and fecal streptococci geometric mean densities exceed 1,000, 100, and 20 per 100 ml respectively (Ministry of the Environment, 1975). In all cases, the 1976 samples indicated that Lac des Mille Lacs waters were well within the Ministry of the Environment criteria for total body contact recreation (Table 1).

TABLE 1. Bacterial Geometric Means (/100 ml) for 5 stations on Lac des Mille Lacs.

Station Number	Background	Total Coliforms	Fecal Coliforms	Fecal Streptococci
1	324.98	3.36	0	1.41
2	73.96	1.41	0	0
3	36.71	3.13	0	2.38
4	147.71	3.72	0	0
5	91.26	4.0	0	1.41

Chlorophyll $\bar{a}$ and Secchi Depth

The approximate relationship between chlorophyll $\bar{a}$ concentrations and Secchi disc depths for a number of Ontario lakes exhibiting a wide variety of characteristics is represented by a hyperbolic-like curve (Figure 2). The relative position of Lac des Mille Lacs on this curve indicates a mesotrophic status when compared to oligotrophic Loch Lomond and eutrophic Lake Erie. The seasonal variation (Table 2) for the most part indicates that a reduction in water transparency was accompanied by an increase in algal abundance.

TABLE 2. Chlorophyll $\bar{a}$ ($\mu\text{g l}^{-1}$) and Secchi Depth (metres) from 7 stations on Lac des Mille Lacs.

Month	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6		Station 7	
	Chlorophyll $\bar{a}$	Secchi Depth	Chlorophyll $\bar{a}$	Secchi Depth	Chlorophyll $\bar{a}$	Secchi Depth	Chlorophyll $\bar{a}$	Secchi Depth	Chlorophyll $\bar{a}$	Secchi Depth	Chlorophyll $\bar{a}$	Secchi Depth	Chlorophyll $\bar{a}$	Secchi Depth
May	2.3	2.0	2.9	1.5	3.7	2.0	1.0	2.0	3.2	1.0	2.0	2.8	2.5	2.4
June	4.4	2.0	3.1	2.0	3.3	2.0	3.0	1.5	2.2	0.5	1.85	2.7	2.3	2.1
July	2.4	2.2	3.7	2.0	2.7	2.3	6.9	1.8	4.6	1.0	4.2	2.4	5.6	2.2
August	4.4	1.5	4.2	1.5	4.3	2.0	3.3	1.5	3.4	1.0	9.2	1.9	6.6	1.6
September											8.5	1.8	8.9	1.5
October											6.5	2.0	3.5	1.9
Mean	3.4	1.9	3.5	1.75	3.5	2.1	3.5	1.7	3.3	0.9	6.1	2.1	5.4	1.86

NOTE: Mean monthly values are given for stations 6 and 7, as well as a mean value for all samples taken.

Physico-Chemical Limnology

Oxygen Concentrations

Thermal regimes and associated oxygen concentrations (Table 3) in 1976 were found to be characteristic of most shallow Northwestern Ontario lakes. Although stratification was evidenced intermittently, it became apparent that the overall pattern was one of instability. Consequently, owing to the shallow nature of Lac des Mille Lacs and the exposure to water circulating winds, oxygen concentrations were found to be only slightly higher in the surface waters than in the bottom waters.

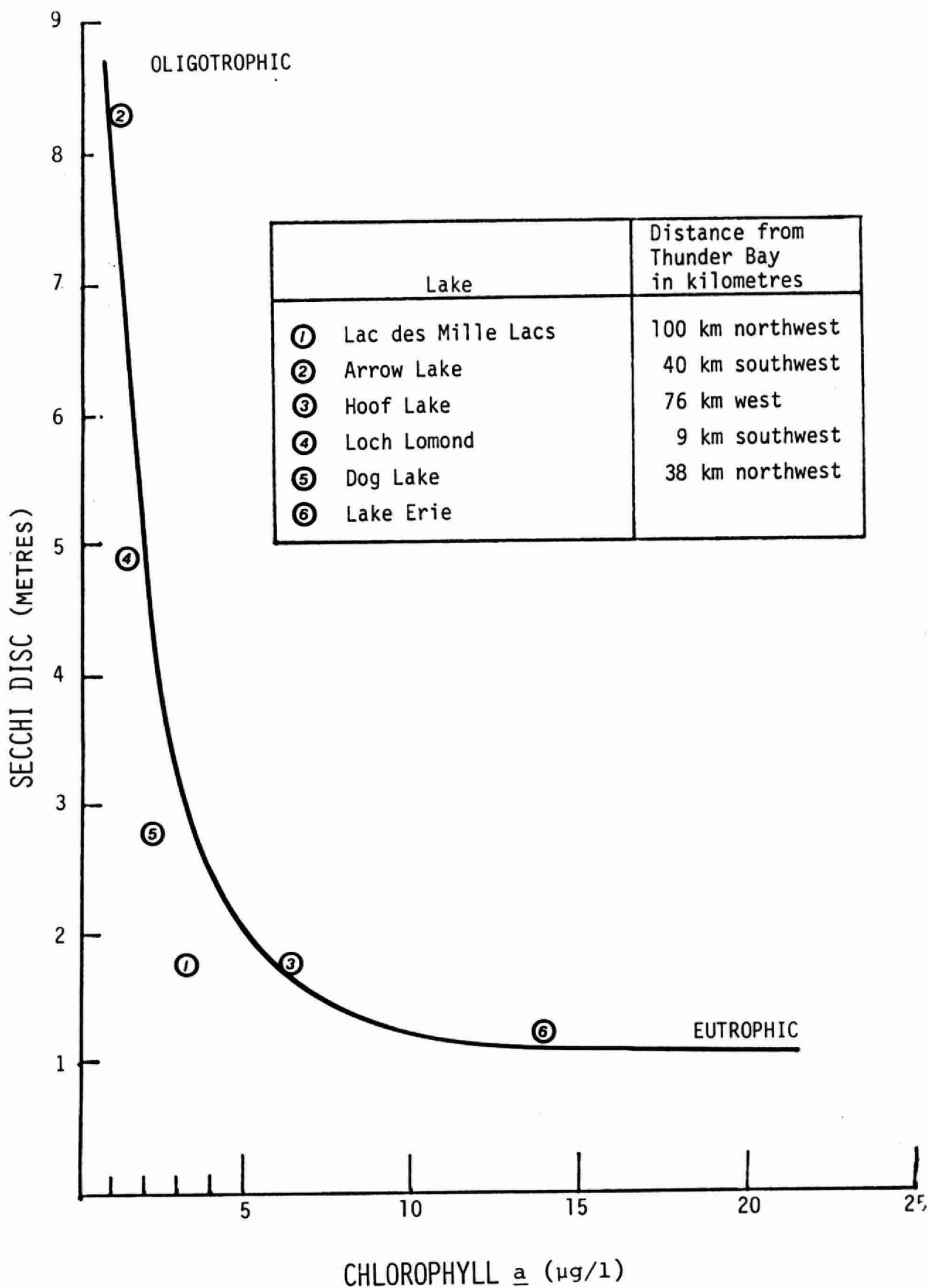


Figure 2. The relationship between chlorophyll a concentrations and Secchi disc depths for Lac des Mille Lacs. The value for the lake is based on the mean values collected during the summer of 1976. Five other Ontario lakes are presented for comparative purposes.

At no time in the 1976 field season were significant oxygen depletions noted in the hypolimnial waters.

TABLE 3. Temperature ($^{\circ}\text{C}$) and oxygen (mg l^{-1}) levels from surface and bottom waters at 5 stations on Lac des Mille Lacs.

Date	Station 1			Station 2			Station 3			Station 4			Station 5		
	Depth (m)	Temperature ($^{\circ}\text{C}$)	Dissolved Oxygen (mg l^{-1})	Depth (m)	Temperature ($^{\circ}\text{C}$)	Dissolved Oxygen (mg l^{-1})	Depth (m)	Temperature ($^{\circ}\text{C}$)	Dissolved Oxygen (mg l^{-1})	Depth (m)	Temperature ($^{\circ}\text{C}$)	Dissolved Oxygen (mg l^{-1})	Depth (m)	Temperature ($^{\circ}\text{C}$)	Dissolved Oxygen (mg l^{-1})
01-06-76	1.0	16.0	9.9	1.0	17.5	10.0	1.0	17.5	10.0	1.0	20.0	9.3	1.0	22.0	8.5
	7.0	12.5	9.0	7.0	15.0	9.8	11.0	11.8	9.9	7.0	13.0	6.8			
19-07-76	1.0	22.0	8.6	1.0	21.5	9.1	1.0	22.0	9.3	1.0	22.5	9.7	1.0	23.2	8.3
	7.0	20.0	8.2	7.0	21.0	9.9	11.0	20.5	9.4	7.0	20.0	3.2			
12-08-76	1.0	22.0	9.0	1.0	21.7	8.8	1.0	21.0	8.8	1.0	21.5	8.5	1.0	21.5	7.6
	7.0	21.0	7.1	7.0	20.3	6.9	11.0	20.0	7.5	7.0	20.0	6.3			

Mean summer concentrations of a variety of limnological parameters (Table 4) generally reaffirm that Lac des Mille Lacs exhibits the characteristic traits of mesotrophy. Furthermore, Lac des Mille Lacs appears chemically typical in all respects of uncontaminated lakes in Northwestern Ontario.

pH and Associated Parameters

The maintenance of near-neutral conditions in mineralized waters is due to buffering by chemical systems such as the carbon dioxide - bicarbonate - carbonate complex (Reid, 1961).

The pH of Lac des Mille Lacs was found to lie between values of 6.0 and 6.6. Although this is slightly acidic, pH values above 5.5 do not normally impede the maintenance of healthy biological systems. The lake, however, is poorly buffered as is evidenced by low alkalinity levels ($20\text{--}22 \text{ mg l}^{-1}$). Low hardness values ($17.3\text{--}25.0 \text{ mg l}^{-1}$) and low

conductivity ($44-48 \mu\text{mho cm}^{-1}$) further attest that Lac des Mille Lacs is inherently incapable of strongly buffering the effects of any major input of acidic materials.

Transparency

Turbidity levels were found to be moderate, ranging from 1.8 to 2.6 Formazin Turbidity Units. Turbidity levels reflect opacity in waters caused by suspended materials which impede light transmission. Colour values were relatively high (43-70 Hazen Units). This factor appears to contribute significantly to the relatively low Secchi depth indicated on Figure 2.

TABLE 4. Limnological data for 5 stations on Lac des Mille Lacs (mean concentrations).

Parameters	Station 1		Station 2		Station 3		Station 4		Station 5	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Acidity	2.0	2.0	2.5	2.0	2.0	2.0	2.5	3.0	2.6	
Alkalinity	20.0	22.0	21.3	20.4	21.3	20.6	20.0	21.3	21.3	
Total Kjeldahl (T.K.N.)	0.45	0.42	0.43	0.42	0.59	0.41	0.44	0.51	0.76	
Ammonia (NH_3)	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.04	0.03	
Nitrite (NO_2)	0.003	0.003	0.003	0.004	0.003	0.004	0.004	0.006	0.010	
Nitrate (NO_3)	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Total Phosphorus	0.022	0.021	0.019	0.022	0.030	0.022	0.020	0.028	0.022	
Turbidity (FTU)	1.8	2.4	1.9	2.6	1.6	1.9	1.7	2.6	3.3	
Sulfate (SO_4)	5.6	5.6	5.3	5.8	5.5	5.5	5.6	4.0	7.1	
Hardness	17.3	20.7	23.3	22.7	21.3	24.0	22.0	22.7	25.0	
pH	6.3	6.1	6.6	6.2	6.6	6.3	6.4	6.0	6.25	
Colour (H.U.)	43.0	47.0	53.0	47.0	46.0	43.0	66.0	70.0	70.0	
Conductivity ($\mu\text{mho/cm}$)	45.0	44.0	44.0	45.0	45.0	46.0	46.0	48.0	47.0	

NOTE: Unless otherwise specified, units for parameters are in mg l^{-1} .

Nitrogen Compounds

Nitrogenous compounds in natural waters may be derived from outside sources (allochthonous) such as in precipitation or surface runoff carrying nitrate and ammonia compounds or may be fixed within the body of water (autochthonous) resulting from fixation processes carried on by certain bacteria and algae (Reid, 1961).

Ammonium (NH_3) levels in Lac des Mille Lacs ranged from .02 to .037 mg l^{-1} indicating a non-toxic environment for aquatic organisms. Many organisms are susceptible to levels exceeding 2.5 mg l^{-1} .

Nitrite (NO_2) and nitrate (NO_3) nitrogen were present in minute quantities characteristic of unpolluted waters: ranges were .003 to .010 mg l^{-1} and .01 to .08 mg l^{-1} respectively.

Total organic nitrogen values (T.K.N.) ranged from .42 to .76 mg l^{-1} and represent high levels of nitrogen or nitrogen compounds associated with organic material. High levels of organic nitrogen are indicative of an elevated level of productivity.

Phosphorus

Of all the elements present in living organisms, phosphorus is likely to be the most important ecologically (Hutchinson, 1957). The concentration of total exchangeable phosphorus in natural water is determined primarily by: (1) basin morphometry as it relates to volume and dilution, and to stratification or water movements; (2) chemical composition of the geological formations of the area as they contribute dissolved phosphate; (3) drainage area features in relation to introduction of organic matter; and (4) organic metabolism within the body of water, and the rate at which phosphorus is lost to the sediment (Reid, 1961).

Although the influence of particular phosphorus forms on lake productivity has not been totally elucidated, recent investigations have indicated that a strong positive correlation exists between total phosphorus concentration at spring turnover and mean summer chlorophyll $\bar{a}$ levels (Dillon and Rigler, 1974). Application of the formula

$$\log_{10} (P) = \frac{\log_{10} (\text{chl } \bar{a}) + 1.14}{1.45}$$

on Lac des Mille Lacs data with mean chlorophyll $\bar{a}$ concentration of 6.1 $\mu\text{gm l}^{-1}$ yields a predicted total phosphorus concentration of 0.021 mg l^{-1} which falls within the measured springtime concentration range (0.015-0.026 mg l^{-1}).

These levels are further indication of moderate biological productivity in Lac des Mille Lacs.

CONCLUSIONS

The conclusions of this preliminary report are as follows:

(1) Results from existing data indicate Lac des Mille Lacs is mesotrophic in nature. (2) Little, if any, impairment in water quality was noted in areas of cottage development as compared with areas where no development existed.

Future study will include the collection of data from stations 8 through 13 which will provide information representing water quality in the lake's western section (Figure 1).

ACKNOWLEDGEMENTS

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